

the vibration transducer to produce a conditioned analog signal;

(b) including a fixed frequency analog anti-aliasing filter having a fixed upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal, said fixed frequency analog anti-aliasing filter being disposed in the conditioning circuit so that all of the conditioned analog signal received by said ADC has been filtered by said fixed frequency analog filter and therefore all of said conditioned analog signal is subjected to the same fixed upper cutoff frequency;

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

Claim 3 (amended). [The system of Claim 1 wherein said conditioning

circuit further comprises:] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal, and further comprising:

(1) a third order sigma-delta modulator having three cascaded sigma-delta loops and having a transfer function substantially of:

$$Y(z) = X(z) + (1-Z^{-1})^3 Q^3(Z)$$

where  $Q^3$  is the quantization noise from the third order sigma-delta loop, said modulator receiving the conditioned analog signal and producing a digital modulator signal;

(2) a comb filter for digitally low-pass filtering and decimating the digital modulator signal from said modulator to produce a comb signal; and

(3) a FIR filter for digitally low-pass filtering and decimating the comb signal to produce the digital signal for said data processor[.];

a data processor mounted in said housing for processing the digital signal to

produce desired digital data, said data processor including:

a transformer for selectively operating on the digital signal,  
performing a Fast Fourier Transform, and producing a frequency spectrum from the  
digital signal;

a selector for selecting and producing select data for storage from at  
least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for  
inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for  
displaying information to the user;

memory interfaced with the data processor for storing information including  
the select data; and

means for transferring information that is stored in said memory to the  
computer.

14  
a2  
cont.  
Claim 1 (amended). [The system of Claim 1 wherein:

said conditioning circuit further comprises] A hand held vibration data  
collector and analyzer system for collecting, analyzing, and storing vibration data that  
is produced by and collected from a predetermined series of machines and for  
transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines  
and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

(a) for receiving and conditioning the analog vibration signal from  
the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency  
set at a desired frequency equal to the maximum vibration frequency of interest for  
producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal

at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal, and further comprising hardware for receiving and sampling the conditioned analog signal at a sample frequency that is substantially greater than a maximum frequency of interest to produce a digital signal, and further for digitally low-pass filtering and digitally decimating the digital signal to produce a conditioned digital signal having a reduced sample rate as compared to the digital signal and a predetermined upper cutoff frequency; [and]

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor further comprising a digital low-pass filter and decimator for optionally and selectively reducing the sample rate and frequency content of the conditioned digital signal to produce a modified conditioned digital signal[.];

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

<sup>16</sup>  
Claim 1 (amended). [The system of Claim 1 wherein said data processor further comprises] A hand held vibration data collector and analyzer system for

collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing:

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for operating on the digital signal to produce a zoom digital signal having a frequency range that is reduced compared to the frequency range of the digital signal[.];

a transformer for selectively operating on the zoom digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the zoom digital signal;

a selector for selecting and producing select data for storage from at least one of the zoom digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

5 Claim <sup>18</sup>6 (amended). [The system of Claim 1 wherein said data processor further comprises:] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing:

10 (a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

15 (c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

20 a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for operating on the digital signal to produce a zoom digital signal having a frequency range that is reduced compared to the frequency range of the digital signal; [and]

a transformer for selectively operating on the zoom digital signal, performing a Fast Fourier Transform, and producing a zoom frequency spectrum from

the zoom digital signal[.];

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

*d2 cont*  
5 Claim <sup>20</sup>7 (amended). [The system of Claim 1 wherein said data processor further comprises] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising;

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

10 (a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

15 (c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

5      a zoom processor for operating on the digital signal by frequency shifting the digital signal and low-pass filtering the frequency shifted digital signal to produce a zoom digital signal corresponding to a selected band of frequencies in the digital signal ranging from a selected upper frequency to a selected lower frequency, both of which are greater than one hertz[.];

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

ad  
cont      a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

27  
5      Claim 2 (amended). [The system of Claim 1 wherein said data processor further comprises] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

10

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

15

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

20

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for operating on the digital signal by multiplying the digital signal by a function to frequency shift the digital signal and low-pass filtering the frequency shifted digital signal to produce a zoom digital signal corresponding to a selected band of frequencies in the digital signal ranging from a selected upper frequency to a selected lower frequency, which is greater than one hertz[.];

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

24  
Claim 6 (amended). [The system of Claim 1 wherein said data processor further comprises] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

5 a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

10 (a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

15 (c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

Q2  
cont (d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

20 a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for producing a zoom digital signal corresponding to a frequency band in the digital signal, said frequency band having an upper frequency, a lower frequency and a center frequency that is centered between the upper and lower frequencies of the band, said zoom processor for frequency shifting the digital signal to shift the center frequency to zero and low-pass filtering the frequency shifted digital signal to produce a zoom digital signal in which the lower and upper frequencies in the zoom digital signal correspond to the lower and upper frequencies in said band, respectively[.];

25 a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the

digital signal:

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

<sup>20</sup>  
Claim ~~10~~ (amended). [The system of Claim 1 wherein said data processor further comprises:] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

<sup>5</sup>  
a2  
cont  
a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

10 (a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

15 (c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for operating on the digital signal by frequency shifting the digital signal and low-pass filtering the frequency shifted digital signal to produce a zoom digital signal corresponding to a selected band of frequencies in the digital signal ranging from a selected upper frequency to a selected lower frequency and having a center frequency;

said zoom processor multiplying the digital signal by a function equal to  $e^{j2\pi f_0 nT}$ , where  $f_0$  equals the center frequency of the selected band and  $f_s$  equals the sample rate of the digital signal, to frequency shift the digital signal such that the center frequency is shifted to zero;

said zoom processor low-pass filtering the frequency shifted digital signal to produce a zoom digital signal in which the lower and upper frequencies in the zoom digital signal correspond to the lower and upper frequencies in said band, respectively[.];

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

<sup>25</sup>  
Claim 11 (amended). [The system of Claim 10 wherein said data

processor further comprises] A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing;

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal;

a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a zoom processor for operating on the digital signal by frequency shifting the digital signal and low-pass filtering the frequency shifted digital signal to produce a zoom digital signal corresponding to a selected band of frequencies in the digital signal ranging from a selected upper frequency to a selected lower frequency and having a center frequency;

said zoom processor multiplying the digital signal by a function equal to  $e^{2\pi i f_0 t / f_s}$  where  $f_0$  equals the center frequency of the selected band and  $f_s$  equals the sample rate of the digital signal, to frequency shift the digital signal such that the center frequency is shifted to zero;

said zoom processor low-pass filtering the frequency shifted digital signal to produce a zoom digital signal in which the lower and upper

frequencies in the zoom digital signal correspond to the lower and upper frequencies in said band, respectively;

a transformer for Fast Fourier Transforming the frequency shifted digital signal to produce a zoom frequency spectrum corresponding to the selected frequency band of the digital signal[.];

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

Claim 26<sup>37</sup> (amended). [The system of Claim 25] A hand held vibration monitoring system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a conditioning circuit:

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including hardware for receiving and sampling the conditioned analog signal at a sample frequency to produce a digital signal, and further for digitally low-pass filtering and digitally decimating the digital signal to produce a conditioned digital signal having a reduced sample rate as compared to the digital signal and a predetermined upper cutoff frequency;

a data processor for digitally processing and analyzing the conditioned digital signal to produce select data for storage, wherein said data processor further comprises a digital low-pass filter and decimator for optionally and selectively reducing the sample rate and frequency content of the conditioned digital signal to produce a modified conditioned digital signal;

a keyboard interfaced with said data processor for inputting commands and data to said data processor;

a display interfaced with said data processor for displaying information to the user;

memory interfaced with said data processor for storing data including the select data; and

means for transferring information stored in said memory to the computer.

Claim 34 (new). A hand held vibration data collector and analyzer system for collecting, analyzing, and storing vibration data that is produced by and collected from a predetermined series of machines and for transferring data to a computer, comprising:

a vibration transducer for sensing vibration that is produced by the machines and for producing an analog vibration signal corresponding to the vibration;

a housing dimensioned and configured for being hand held;

a conditioning circuit mounted in said housing:

(a) for receiving and conditioning the analog vibration signal from the vibration transducer to produce a conditioned analog signal;

(b) including an anti-aliasing filter having an upper cutoff frequency set at a desired frequency equal to the maximum vibration frequency of interest for producing the conditioned analog signal having a desired frequency range;

(c) including amplifiers for producing the conditioned analog signal at a desired amplitude;

(d) including an analog to digital converter (ADC) for receiving and sampling the conditioned analog signal to produce a digital signal, and further

comprising;

(1) a sigma-delta modulator having a number of cascaded sigma-delta loops and having a transfer function substantially of:

$$Y(z) = X(z) + (1-Z^{-1})^n Q^n(z)$$

where  $Q^n$  is the quantization noise from the sigma-delta modulator and  $n$  is the number of cascaded sigma-delta loops, said modulator receiving the conditioned analog signal and producing a digital modulator signal;

(2) a comb filter for digitally low-pass filtering and decimating the digital modulator signal from said modulator to produce a comb signal; and

(3) a FIR filter for digitally low-pass filtering and decimating the comb signal to produce the digital signal for said data processor; a data processor mounted in said housing for processing the digital signal to produce desired digital data, said data processor including:

a transformer for selectively operating on the digital signal, performing a Fast Fourier Transform, and producing a frequency spectrum from the digital signal;

a selector for selecting and producing select data for storage from at least one of the digital signal and the frequency spectrum;

a keyboard mounted in said housing interfaced with said data processor for inputting commands and data to said data processor;

a display mounted in said housing interfaced with said data processor for displaying information to the user;

memory interfaced with the data processor for storing information including the select data; and

means for transferring information that is stored in said memory to the computer.

Claim 32 (new). The system of Claim 1 further comprising a digital filter for digitally filtering the digital signal to produce a modified digital signal.

<sup>13</sup>  
Claim 33 (new). The system of Claim <sup>12</sup>~~3~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>15</sup>  
Claim 34 (new). The system of Claim <sup>14</sup>~~4~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>17</sup>  
Claim 35 (new). The system of Claim <sup>16</sup>~~5~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>19</sup>  
Claim 36 (new). The system of Claim <sup>18</sup>~~6~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>21</sup>  
Claim 37 (new). The system of Claim <sup>20</sup>~~7~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>23</sup>  
Claim 38 (new). The system of Claim <sup>22</sup>~~8~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>25</sup>  
Claim 39 (new). The system of Claim <sup>24</sup>~~9~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>27</sup>  
Claim 40 (new). The system of Claim <sup>26</sup>~~10~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>29</sup>  
Claim 41 (new). The system of Claim <sup>28</sup>~~11~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

<sup>31</sup>  
Claim 42 (new). The system of Claim <sup>41</sup>~~12~~ wherein the anti-aliasing filter further comprises a fixed frequency analog filter.

52<sup>18</sup>